Ascribing blame in car, motorcyclist & pedestrian collisions

Some critical observations about human visual processing

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A. A car is travelling at 30mph, in a 30mph zone approaching a primary school, a 9yr old walking to school steps off the pavement and the driver has to brake hard to avoid an accident.

B. A driver in his late 70s is at a T junction waiting to join an A road, he pulls out and accelerates but a car appears rapidly behind him flashing its lights and a tail-end collision occurs.

C. A women in her 20s is at a junction, waiting to join an A road at 6pm on a winter evening. She pulls out, but a motorcycle seems to come from nowhere down the main carriageway and has to swerve to avoid her.

To consider these I’d like to take a step back and ask how we make reliable judgements about vehicle approach
How do you judge speed and distance?

- **Perspective**
  - Unreliable
- **Stereo Cues (3D)**
  - Unreliable
- **Optical Size**
- **Height in the Scene**
  - Unreliable
- **Optical Expansion (Looming)**
Sensitivity to looming

All animals are responsive to optical looming $\dot{\theta}$: Flies; Locusts, Gerbils, Pigeons. It has been shown that the “nucleus rotundus” responds to $\dot{\theta}$ and fires 1 sec before an object would hit the pigeon.

Our own work with brain imaging has shown that subcortical neural areas in the human can respond as a similar ‘alarm system’ to that of the pigeon.

BUT all animals have limits to their sensitivity to any perceptual variable, and we don’t know when $\dot{\theta}$ is below the level at which humans can reliably detect in road scenes.
A little essential maths…

For a vehicle approaching an observer waiting to cross/pull-out…..

\[ \dot{\theta}(t) = \frac{S \cdot v(t)}{Z^2(t)} \]

Looming is dictated by the size \( S \) of the vehicle, is velocity \( V \) and its distance \( Z \), larger vehicles loom MORE, faster vehicles look MORE

\[ \dot{\theta}(t) = \frac{S}{t_c^2 \cdot v(t)} \]

But if we reset the equation in terms of the TIME the observer needs to cross/pull-out. Velocity \( v \) moves to the divisor. So larger vehicles still loom MORE, BUT faster vehicles loom LESS than slower vehicles

Note: This is because to give a waiting pedestrian a time-gap of 4secs to cross a road a vehicle at 50mph needs to be TWICE as far away as a vehicle travelling at 25mph, which leads to half the image size and half the looming rate

If you measure sensitivity you can establish critical vehicle speeds above which an observer is likely to make a misjudgement
So how do we measure human sensitivity?

Example adaptive track following best-PEST procedure

- e.g. 120mph vs 20mph
- e.g. 30mph vs 20mph
So how do we measure human sensitivity?
Factors which can affect the critical speed at which errors are made

- Age of observer: Adult, Older Adult, Child: Different Sensitivities?
- Visibility: Daytime, Dusk, Night-time, Fog.
- Size of vehicle: Truck, Car, Motorcycle: (S):

\[ v_{\text{max}} = \frac{S}{t_c \cdot \dot{\theta}_{th}} \]

Studies:
- Young (21-40yrs) vs. 40-70yrs vs. Older Drivers (75+); screened for major visual deficits.
- Motorcycles at daytime, dusk and night-time.
- Children 6-7yrs, 8-9yrs, 10-11yrs (n = 111).

Basic paradigm: Can you tell the difference between a set speed (e.g. 20mph or 30mph) and a vehicle approaching faster than that?
Factors which may affect judgments: Age & Vehicle Size

Older drivers/P can only tell difference between 20mph & 45mph (reduces pull out time by ~50%)

For motorcycles, older drivers/P have difficulty distinguishing between 20mph & 60mph

All drivers/P make errors, reducing available action time

Older drivers/P make greater speed judgment errors than younger drivers

...despite similar confidence levels when asked how good they thought they were in making judgments this type of road situation

Younger drivers can just tell difference between 20mph & 30mph

Speed difference required to notice probe vehicle is travelling faster than reference vehicle (with 95%CI)
Factors which may affect judgments

IAM Report on Elderly drivers 2010

Increase in KSI events over 70 yrs correlates with decrease in perceptual sensitivity
Factors which may affect judgments: MCs & Lighting Conditions

Motorcycles provide a smaller visible profile (S), even with a yellow safety vest.

At night-time this may shrink to ~30cm, whereas a car has 2 headlights 1.5m apart.

\[ v_{\text{max}} = \frac{S}{t_c \hat{\theta}_{\text{th}}} \]

Max speed of approach at which you can make a reliable judgment.
Factors which may affect judgments: Lighting Conditions

As night-time or fog conditions reduce motorcycle visibility down to just the headlight, judgments of arrival time become more erroneous, as would be predicted from judgments based on looming.

For motorcycles the errors can be partially offset by a different lighting configuration.

The same pattern occurs even if the motorcyclist is wearing a yellow vest.

The same type of error increase could occur for cars with just one headlight.
The problem of children and road crossing

A report by the World Health Organisation highlighted that road traffic accidents are the 3rd leading preventable cause of fatality and disability, particularly in children (WHO, 2007).

Children’s visual limitations in judging speed & distance have been suggested as a key deficit (WHO, 2007).
112 school children (6-7, 8-9, 10-11yrs)

Younger children can only just tell difference between 20mph & 50mph

When vehicles are different sizes, all children have difficulty distinguishing between 20mph & 60+mph

All pedestrians make errors, reducing available action time

Younger children make greater speed judgment errors than older children or adults

Speed difference required to notice probe vehicle is travelling faster than reference vehicle (with 95%CI)

Older children (10-11yrs) can just tell difference between 20mph & 40mph

Adult Performance

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**Mean speed difference (mph)**

- 6-7yrs
- 8-9yrs
- 10-11yrs
- Adult

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**Car vs. Car Faster car vs. truck**

Condition

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**112 school children (6-7, 8-9, 10-11yrs)**

- All pedestrians make errors, reducing available action time
- Younger children make greater speed judgment errors than older children or adults
- Older children (10-11yrs) can just tell difference between 20mph & 40mph

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**Royal Holloway**

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The problem of children and road crossing

- Children’s perceptual acuity in primary school significantly below adult performance levels.
- Younger children unable to reliably detect cars 5s away approaching >25mph if their head is in motion when looking down the road &/or they fail to fixate directly on approaching car.
- When they do detect vehicles they are unable to discriminate between cars at 20mph and those at 48mph, even though a car >40mph has reduced their crossing time by 50%.
- These errors are increased in children with developmental disorders, such as Dyspraxia.

- Zones limited to 20mph are used sparsely in the UK, and internationally, often only for very short distances. Many schools have 30 or 40mph roads surrounding them.
- We measured vehicle speeds directly outside each school which and they ranged from 21mph to 51mph with an average speed of 34mph.
This study shows that the problems are not just about children paying attention and following procedure. Immaturity in low-level detection mechanisms mean that children cannot reliably judge the approach of vehicles in the upper range of urban speeds.

Related errors can occur in older drivers (75+ yrs) in judging their pull-out from junctions, due to a decline in their detection & discrimination mechanisms.

We can predict "failed to notice" errors relating to drivers detecting & judging motorcycle approach. An adjustment of the motorcycle lighting pattern can reduce these errors.

Max speed of approach at which a reliable judgment can be made:

\[ v_{max} = \frac{S}{\dot{\theta}_h \tau_c} \]

Vehicle size
Sensitivity of observer
A specific set of issues for cyclists

\[ V_{\text{max}} = \frac{S}{t_c^2 \dot{\theta}_{\text{th}}} \]

Max speed of approach at which a reliable judgment can be made

- Tail-end “failed to notice” accidents.
- Junction pull-out “failed to notice” accidents.
- Poor judgments in “close passage” errors
- Poor judgments in “turn-across path” accidents
The policy issues

These will be errors by the child trying to cross the road, or the driver/cyclist trying to pull out, but often they will be caused by the speed of approach of the other vehicle (which pushed the judgment task out of the reliable range). BUT the driver of the approaching vehicle will attribute blame to the person pulling out or stepping out.

A. A car is travelling at 30mph, in a 30mph zone approaching a primary school, a 9yr old walking to school steps off the pavement and the driver has to brake hard to avoid an accident.   **Driver awareness of the capability of others.**

B. A driver in his late 70s is at a T junction waiting to join an A road, he pulls out and accelerates but a car appears rapidly behind him flashing its lights and a tail-end collision occurs.  **Driver awareness of their own capabilities (re-testing at 75,80,85yrs ?).**

C. A women in her 20s is at a junction, waiting to join an A road at 6pm on a winter evening. She pulls out, but a motorcycle seems to come from nowhere down the main carriageway and has to swerve to avoid her. **Manufacturer awareness of the risks created**
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